

AD-A193 321 SIGNATURE SUPPRESSION KITS FOR THE MIL-STD 10KM 1/1  
GASOLINE DRIVEN ENGINE-GENERATOR SET(U) AREA THERM CORP  
LORTON VA E F ALLARD MAR 88 ATC-60 DAAK78-83-C-0161

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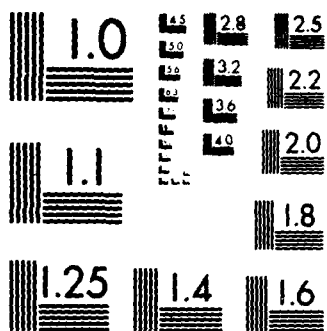
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SIGNATURE SUPPRESSION KITS  
FOR THE MIL-STD 10KW  
GASOLINE DRIVEN ENGINE-GENERATOR SET

Final Report ✓  
ATC-60 ✓

DTIC  
ELECTE  
APR 14 1988  
S D

By  
Edward F. Allard

Area Therm Corporation  
7351-H Lockport Place  
Lorton, Virginia

Under Contract to  
US Army Mobility Equipment  
Research and Development Command  
Fort Belvoir, Virginia

Contract No. DAAK70-83-C-0161

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March, 1986

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## TABLE OF CONTENTS

1.0	Introduction	1
1.1	Project Objectives	1
1.2	Methodology	1
1.3	Outline of Report	2
2.0	Theoretical Considerations	2
3.0	Description of Suppressor	7
4.0	Testing	9
4.1	Introduction	9
4.2	Materials Testing	9
4.3	Temperature Testing	10
4.4	Acoustical Testing	11
4.5	Fitting Suppressors on E-G Set	11
4.6	Trailer Mounting and Testing	12
5.0	Data	13
5.1	Muffler Data	13
5.2	Bare Set Data	14
5.3	Suppressed Set	14
5.4	Temperature Data	15
6.0	Results	16
7.0	Conclusions	16
8.0	Technical Discussion	17
9.0	Recommendations	17
	Figure 1	19
	Figure 2	20
	Figure 3	21
	Figure 4	22
	Figure 5	23
	Figure 6	24
	Figure 7	25
	Figure 8	26

## 1.0 INTRODUCTION

This report describes the work performed by Area Therm Corporation under USAMERADCOM No. DAAK70-83-C-0161. The work was performed at ATC between 22 September 1983 and 30 April 1985.

### 1.1 Project Objectives

The project objectives of this report were:

- (1) To conduct investigations on thermal and acoustical signatures of the 10KW, 60HZ Model 018A Gasoline Engine Driven generator sets as mounted on the 619/M trailer.
- (2) To build experimental suppressors for the 10KW E-G sets and to test these suppressors.
- (3) To fabricate and deliver suppressors for two trailers.
- (4) To fabricate and deliver kits for four additional E-G sets.
- (5) To provide a data package.

### 1.2 Methodology

The thermal and acoustical signatures of one 10KW E-G set were measured at ATC. The Government's primary goal was to acoustically suppress the 10KW and to accept any thermal suppression as a result of the acoustical work. ATC measured the acoustical signature of the bare 10KW with and without its standard muffler. It was clear that the standard muffler was a dominating noise source and had to be replaced. ATC had another muffler built which dropped the muffler noise below the engine noise. The standard muffler had a 90dBA noise level at 7m and the ATC muffler had an 80dBA level. Noise signature data showed that the relatively large engine fan spinning at 3600 rpm was the dominating noise source for the entire set. This area was suppressed by surrounding the fan with a shroud

composed of heavy metal and absorbing material. Since the fan was designed to draw cool air through the generator, fan noise traveled along the open areas in the generator and out through the generator air intake. This area had to be suppressed also. Suppression was accomplished by utilizing a generator air intake silencer. Fan noise escaped into all areas around the engine shroud. All these areas were suppressed by enclosing the engine in a metallic container. Duct work was designed into the container so that the engine cooling air from the fan could be captured and directed away from the set without overheating the engine. Considerable effort went into the duct design to assure that the engine would not overheat at full load.

### 1.3 Outline of Report

This report has been organized into the following sections:

Section 2 describes theoretical considerations of acoustical suppression.

Section 3 describes the design of the suppressor.

Section 4 describes the testing.

Section 5 presents the data.

Section 6 states the results.

Section 7 discusses the results and conclusions to be drawn.

Section 8 presents a short technical discussion.

Section 9 recommends future work.

## 2.0 THEORETICAL CONSIDERATIONS

The measurement of noise levels has been standardized so that data from one design to another can be compared.

The accepted standard is the decibel on the "A" scale, written dBA. In addition, dBA readings are taken at 7 meters away from the noise source. However, many experimenters take readings from 1 meter so that bounced noise from walls or buildings are second order effects compared to the noise coming directly from the source. The dBA scale is a weighted average which approximates the response of a human ear. The human ear is not as sensitive at lower frequencies (below 250 HZ) as at frequencies near 1000HZ and above. Acoustical material manufacturers have developed materials that have good absorption characteristics near 1000HZ but not so good below 250HZ. Unfortunately, engines have high noise power below 250 HZ and this fact makes it difficult to suppress noise at these lower frequencies. The best approach to suppressing lower frequency noise is to eliminate the origin of the noise or to suppress the noise as close to the origin as possible.

The 10KW E-G set has high noise levels at the lower frequencies. Some of this noise comes from the standard muffler. ATC attacked this problem by having Alexander-Tagg Corporation build a new muffler to ATC's requirement that the muffler should be optimized for low frequencies. The new Alexander-Tagg muffler suppressed all the low frequencies 13dBA below the standard muffler. The overall dBA level was also 13dBA below the standard muffler. The suppression of the muffler shifted the dominant noise source from the muffler to the engine fan.

The engine fan was the dominant noise of the 10KW set.



Its rotation at 3600 rpm radiated noise in all directions. Since this fan drew air into the generator through the generator air intake, noise radiated from the generator air intake. The fan noise was greater than the generator noise. A generator air intake silencer was designed and fit onto the end of the generator. This suppressed the generator end of the set. Without this silencer no reasonable suppression was possible. The fan area was suppressed by encasing the fan in a 12 gauge silencer. The inside of this silencer was lined with acoustically absorbing material. The air intake to this fan silencer was a lined duct through which intake air was drawn from the generator end of the set. Without this lined duct, suppression of the fan was not possible. Since the fan cooled the engine by forcing air through shrouds on the engine, fan noise radiated through the shrouds and under the E-G set. In order to suppress the fan noise and engine noise, a metallic housing was designed to surround the engine. The housing was sealed to the fan silencer to prevent noise leaks and was sealed to a bottom "noise trap" to prevent noise from leaking there. At this point the design included a silencer for the generator air intake, a fan suppressor, a silencer for the fan air intake, an engine enclosure and a bottom sound trap.

The problem shifted from acoustical suppression to engine cooling. In reality, several engine enclosures were built and tested. It was most important that an applied enclosure should not overheat the engine. An enclosure was selected which did not overheat the engine. Overheating was carefully monitored by measuring temperatures.

Since the engine enclosure had to provide holes whereby the engine cooling air could escape, these holes became noise sources. It would have been impossible to suppress the set without suppressing these holes. The holes, one on each side of the engine enclosure, were suppressed by applying a curved silencer to each hole. The curved silencer directed the engine cooling air (hot air exiting from the bottom of the engine enclosure) up the side of the enclosure and then turned the air again towards the front of the enclosure. The air was turned twice, thus the noise was turned twice. This design produced noise suppression beyond expectations. In reality, several of these curved silencers were built and tested. The accepted silencer was selected on the basis of engine cooling. The accepted curved silencer did not overheat the engine.

The suppressor had the following major components: generator air intake silencer, fan enclosure, fan air intake silencer, engine enclosure, bottom noise trap, and two silencers for the exiting, engine cooling air. Mr. William Summerson, the Contracting Officer's Technical Representative, directed that all these components should not interfere with normal maintenance. Also, the components should fit onto the 10KW without changing the existing parts on the set. These requirements forced ATC into designs that were not simple. The engine enclosure and associated ducts could be dismantled in about 20 seconds. This design required hinges, latches, and seals. Seals were a problem. If there is an air leak between two metal surfaces, there will be a sound leak. If there is no air leak, there still may be a sound leak. ATC found that individual 10KW E-G sets

were not put together in exactly the same way. Since there was no E-G requirement to fit parts with close tolerances, some parts were located at slightly different positions from set to set. Thus, when ATC made a complete suppressor with tight fitting for one particular set, it was found that an identical suppressor would not fit easily onto another set because the other set was not identical to the original set. This meant that the design would have had to be changed to loosen the fitting specs on the suppressors. The contract ran out of money before this could be done.

The trailer on which two 10KW E-G sets are mounted has an outstanding thermal signature. This is due to the E-G sets themselves and to the hot engine cooling air that blows inside the trailer. Normally these trailers are deployed with a canvas roof. The hot air swirling inside the trailer heats up the canvas. In order to keep the engines from overheating, the sides and end of the trailer are opened to allow outside air to cool the engines. These open areas are hot areas because the hot E-G sets can be seen. The ATC acoustical suppression design helps the thermal signature problem. Firstly, cool air is drawn into the trailer due to the fan intake. All hot air is directed out from the trailer via the engine cooling air duct. No hot air circulates inside the trailer. Secondly, the hot muffler of the 10KW is placed under the trailer towards the center. This masks the muffler so that it cannot be seen. The hot exhaust gases are blown underneath the trailer. Some ground heating is masked. Thirdly, the set is thermally suppressed except for the exit parts of the engine cooling air.

### 3.0 DESCRIPTION OF SUPPRESSOR

The suppressor was designed and built under the guidance of Mr. William Summerson. Mr. Summerson advised ATC that the military was interested in a kit type suppressor which would allow quick access to the engine for maintenance. In addition, Mr. Summerson advised that the military was not interested in an enclosure which would completely enclose the 10KW. This design philosophy required ATC to devise a design which would disassemble quickly. But quick disassembly demands more hinges, seals, latches, etc. which are sources of sound leaks. Nevertheless, a design to meet these requirements produced an surprisingly high performance suppressor.

A drawing of the suppressor is found in the figure section of this report as Figure 8. In this figure air for the generator is drawn in through the generator silencer. Air for the engine is drawn in through the engine intake silencer. A fan, located between the engine and generator, draws the intake air and forces the air around shrouds on the engine. The air from the shrouds is captured by side suppressors and directed into the engine cooling air suppressor. The muffler is placed under the set.

The suppressor has a bottom pan "noise trap" which seals engine noise from leaving the bottom of the set. This bottom pan has short sides which form an attaching mechanism for the two side suppressors and the front panel suppressor. The two sides and front panel can be attached in about 10 seconds.

When the two sides and front panel are attached, the engine cooling air suppressor, which is made in two parts, can be attached to the sides in about 5 seconds. Finally, the sides are latched to the front panel and the engine cooling air suppressors are latched together. The whole operation takes about 20 seconds. There is a metal shroud around the engine fan, located between the engine and generator. This shroud cannot be removed without lifting the 10KW off its skid. Attached to this shroud is the engine intake silencer. This silencer can be removed in about 10 seconds. The generator silencer is attached with bolts. It can be removed in about 1 minute. In summary, the generator silencer, engine intake silencer, side suppressors, front panel, and the engine cooling air suppressors are removeable. The bottom fan and sides and the fan shroud are not removable without lifting the 10KW off the skid.

#### 4.0 TESTING

##### 4.1 Introduction

Basically, the following types of tests were performed:

- acoustical testing of materials
- temperature testing of the E-G set
- acoustical testing of suppressors
- fitting of suppressors on different sets

Having experience in the testing of various suppressors, ATC was very careful to assure that no component of a suppressor would cause engine overheating. A suppressor cannot be considered successful if it overheats the engine. More time was devoted to designing and testing for engine cooling than any other aspect of the program. There exists several suppliers of acoustical absorbing material, but some are not suitable for application around hot engines. ATC built a test rig to test various materials and one material suitable for the hot areas was used in the suppressor. Noise measurements of suppressor performance were performed indoors and outdoors.

##### 4.2 Materials Testing

ATC designed and built a test rig for acoustical testing. The rig was a large cylindrical pipe with a  $\frac{1}{4}$  inch thick steel wall. A noise source was placed inside the pipe. Acoustical measurements around the pipe showed that the steel opening at one end was 20dBA higher than outside the walls. The noise source was calibrated one foot from the opening. Various acoustical absorbers and barriers were sealed onto the pipe's opening and compared to the calibrating standard. ATC found

that most commercial absorbers were very close in performance. Fiber glass absorbers performed about the same as foam absorbers. A high temperature foam performed as well as fiber glass and standard foam. These results showed that any of the commercial products could be used from a noise viewpoint but some products could not be used near high temperature components. In addition to testing absorbers, various rubber strips were tested for noise sealing capability. Preliminary tests showed that pressure on the rubber seals had a greater effect than variations in material composition from seal to seal. No "spongy" type material was useful as a seal.

#### 4.3 Temperature Testing

ATC spent more time on engine cooling testing than any other part of the program. ATC had been informed by government engineers that the 10KW tended to overheat on the trailer unless all the trailer sides were open. This condition was probably due to the fact that engine cooling air was blown in all directions and probably was recirculated back into the air intake. ATC measured various temperatures and monitored engine heating with and without suppressors. ATC measured temperatures at the following positions: spark plugs, oil sump, dip stick, carburetor air intake, generator air intake, generator air output, engine cooling air intake and engine cooling air output. From the beginning ATC had problems with spark plug#2. The bare set drove this temperature to 421°F and beyond. The suppressed set drove this temperature to 464°F and beyond. Other than this point, the suppressor did not drive temperatures

significantly beyond the bare set values. After many experiments, ATC found that one hour of continuous operation was sufficient to establish stabilized conditions. All temperature data are referenced to stabilized conditions.

#### 4.4 Acoustical Testing

Acoustical testing of the 10KW with and without suppression was performed with an octave band analyzer. This instrument is standard equipment. It measures noise levels around the accepted, standard frequencies of 63, 125, 250, 500, 1000, 2000, 4000, 8000HZ, and the A-scale. Since microphones detect both direct and reflected noise, noise measurements inside a building were measured one foot or one meter away from the set. Direct noise in ATC's laboratory was 6dBA higher than the reflected noise, so the reflected noise was ignored for level of accuracy demanded by these measurements. Outside the building, measurements were taken at 7 meters away from the set. It was not always possible to measure 7 meters from all directions due to building walls, cars, trucks, etc. Measurements on black top roads near buildings, cars, trucks, etc., will always be higher than measurements in an open field.

#### 4.5 Fitting Suppressors on E-G sets

To ATC's surprise, it was learned that all 10KW E-G sets are not constructed to tight tolerances. Tight tolerances on the positions of parts is not necessary for the unsuppressed sets. However, it is assumed that production suppressors will fit on any set and this is not possible if each set is not put



together exactly the same way. A tightly fitted suppressor kit was designed for one 10KW. This same kit was fitted onto another 10KW with only minor problems. The tolerances on this kit were used to construct 5 additional kits (suppressors). When the Government delivered two additional trailers and 4 additional 10KW E-G sets, ATC found that the kits did not fit properly on the new (rebuilt) sets because the rebuilt sets were not the same as the two original sets. However, after some adjustments to the kits, they did fit onto the new sets. ATC recommended that before additional kits be built looser tolerances should be incorporated into the kits.

#### 4.6 Trailer Mounting and Testing

ATC mounted two kits on each of two trailers. Both for safety and thermal suppression, the two mufflers on each trailer were mounted under the trailer. This required that the exhaust pipe on each engine be bent downwards and bent again under the trailer. Nelson mufflers designed to ATC's specs, were mounted. Acoustical test data showed that the noise from one of these mufflers when mounted under a trailer was lower than the suppressed noise from one of the E-G sets. Due to the suppressor design, it was observed that hot air did not circulate inside the trailer. Hot exhaust air was blown out and away from the set and cool was drawn in from the sides. This cool air circulation was the best that could be obtained for trailer mounted suppressors.

## 5.0 DATA

ATC took considerable data for each phase of suppressor development. Acoustical data were taken up close to the E-G set and at 7 meters. Since data were taken indoors, it was necessary to record data from one meter away from the set or closer. Load bank noise and wall reflections could be ignored for this measurement distance. Outside the building, the load bank had to be placed as far away as possible. In some cases the load bank was kept inside the building while the set was measured outside. Even when the set was outside, building reflections had to be considered when measurements were made from 7m. Data reported in this report for a 7m distance will be lower when measured in an open field.

### 5.1 Muffler Data

ATC measured various mufflers. The problem of measuring noise from a muffler was that the muffler had to be isolated from the engine and reflected noise had to be minimized. ATC constructed a test chamber which actually was two 55 gallon drums welded together end to end. One end had a hole for the exhaust pipe and the other end was open. The drum was lined with acoustical fiberglass. This drum was located outside a building with a thin metallic door separating the engine from the drum. Figure 1 shows the 10KW noise level with no muffler. The standard muffler dropped the overall level by 8dBA. The ATC specified muffler dropped the noise level by 21dBA. Notice the large drop at the lower frequencies. The measurements

were taken one foot from the exit ends of the mufflers.

### 5.2 Bare Set Data

From Figure 2 it can be seen that the engine area was noisier than the generator area as expected. The area above the engine was 10dBA noisier than the rest of the engine at 125HZ. This frequency component is the most difficult to suppress. Notice that the ATC muffler data in figure 1 suppressed this frequency in the muffler. The average dBA reading is 102dBA.

### 5.3 Suppressed Set

As a comparison for Figure 2, consider Figure 3. These data show the suppressed set at one foot. The average dBA reading = 85.5 dBA. This should be compared with the average of 102dBA. Thus, the suppressor produces a drop of 16.5dBA on the average. Notice that the muffler in each case did not contribute to the noise.

Figure 4 shows data taken from the noisy end of a suppressed set. The suppressed set was on a black top road with a building about 3 meters behind it and a building about 12 meters in front of it. The muffler was placed under the set to simulate its position on a trailer. An average of 72dBA was measured. Calculations show that the effects of this particular surrounding add from 4 to 5dBA to the sound levels. The data show that at point 4 the reading was 2dBA above point 5. The cause of this difference was a bad seal at point 4. Through numerous experiments after this discovery, it was determined that loose seals (tight to the eye) could increase the noise level from 2 to 4dBA.

Figure 5 shows the suppressor after seals were redesigned. Notice that the average value at 7m is 70.9dBA. However, the background noise was near 70.5dBA. It has been ATC's experience that a 12dBA drop can be expected from one meter to 12 meters. ATC made only quick measurements on a suppressor mounted on a trailer before it went to Ft. Hood. A reading of 67dBA was measured at 7m from the engine end.

#### 5.4 Temperature Data

More time was spent measuring temperature than any other tests. The effect on E-G temperatures for each change in suppressor design was carefully monitored. During the testing, problems with measuring spark plug temperatures was a constant headache. The spark plug thermocouples might not have been accurate. ATC did not have a calibrating facility for these thermocouples. Figure 6 shows a typical spread of temperatures for a bare 10KW under load (all full loads were 9KW). What was supprising to ATC was the relatively high temperature for the carborator air intake for an ambient air of 69°F. Figure 7 is typical of the spread in temperatures for a suppressed set at an ambient close to 63°F. It was difficult to set up the some temperature conditions for the bare set and the suppressed set due to the differences in air circulation between the two. The generator air intake was selected as the ambient temperature. If it be assumed that the bare set was in an ambient 6°F warmer than the suppressed set, then 6°F should be added to the sump, dip stick and carborator air intake for comparison. When this is done, the data show that the

suppressor did not overheat the engine. The one noticeable exception is the spark plugs, but their true temperatures are in doubt.

## 6.0 RESULTS

6.1 The data show that ATC had mufflers built that suppressed muffler noise below the suppressed level of the 10KW.

6.2 The data show that the suppressor did not overheat the 10KW when compared to a bare set at approximately the same ambient temperature.

6.3 Sound suppression levels of 70dBA and lower were accomplished. The suppression difference was from 17-20dBA.

6.4 The suppressor was made in kit form which allows it to be dismantled in about 30 seconds for routine maintenance.

6.5 All 10KW's are not put together with tight tolerances making this particular design difficult to fit onto any set.

## 7.0 CONCLUSIONS

7.1 The seemingly impossible goal of 70dBA measured at 7 meters was achieved and was surpassed in fact. This was done without enclosing the entire set.

7.2 The suppressor did not significantly increase the 10KW operating temperatures.

7.3 The kit form of the design allows for rapid access for maintenance.

7.4 The design eliminates recirculation when the set is mounted on a trailer, thus helping the cooling problem.

7.5 The design reduces but does not eliminate the thermal signature problem.

## 8.0 TECHNICAL DISCUSSION

The suppression goal for this contract was 70dBA at 7 meters. Such a goal required a drop in noise level about 15dBA. The actual results were below 70dBA which was surprising because a kit type design should be noisy due to numerous seals, hinges, latches, etc. ATC simply worked hard at eliminating noise leaks. The tight seals performed very well, but created a problem when one kit was switched to other E-G sets. It was found that tolerances for assembling 10KW sets were too loose for the tight tolerances of the suppressor design and this caused a fitting problem. No exotic materials were used; only off-the-shelf metal and acoustical materials were used. Standard latches, hinges, bolts, etc. were off-the-shelf. A conclusion is that excellent sound suppression can be achieved with off-the-shelf components and hard work.

Engine cooling is always a problem with acoustical suppressors. ATC constantly monitored engine temperature to assure that no serious overheating would occur due to an acoustical design. Every acoustical design without exception was tested for engine overheating. The final design was tested to the best of ATC's capability and test results showed that no serious overheating should occur due to the suppressor.

## 9.0 RECOMMENDATIONS

At this time the Government has an excellent suppressor for the 10KW E-G set. All that is required to develop the suppression for production is to build a few sets to address

the fitting problem.

ATC would be willing to continue the work in order to bring the program up to a production level of development.

dB

110

100

90

80

70

60

Muffler Acoustical Signature- 10KW

No Muffler ○ ○ ○  
Standard - - -  
A.T.C. \* \* \*

dB

-100

-90

-80

63

125

250

500

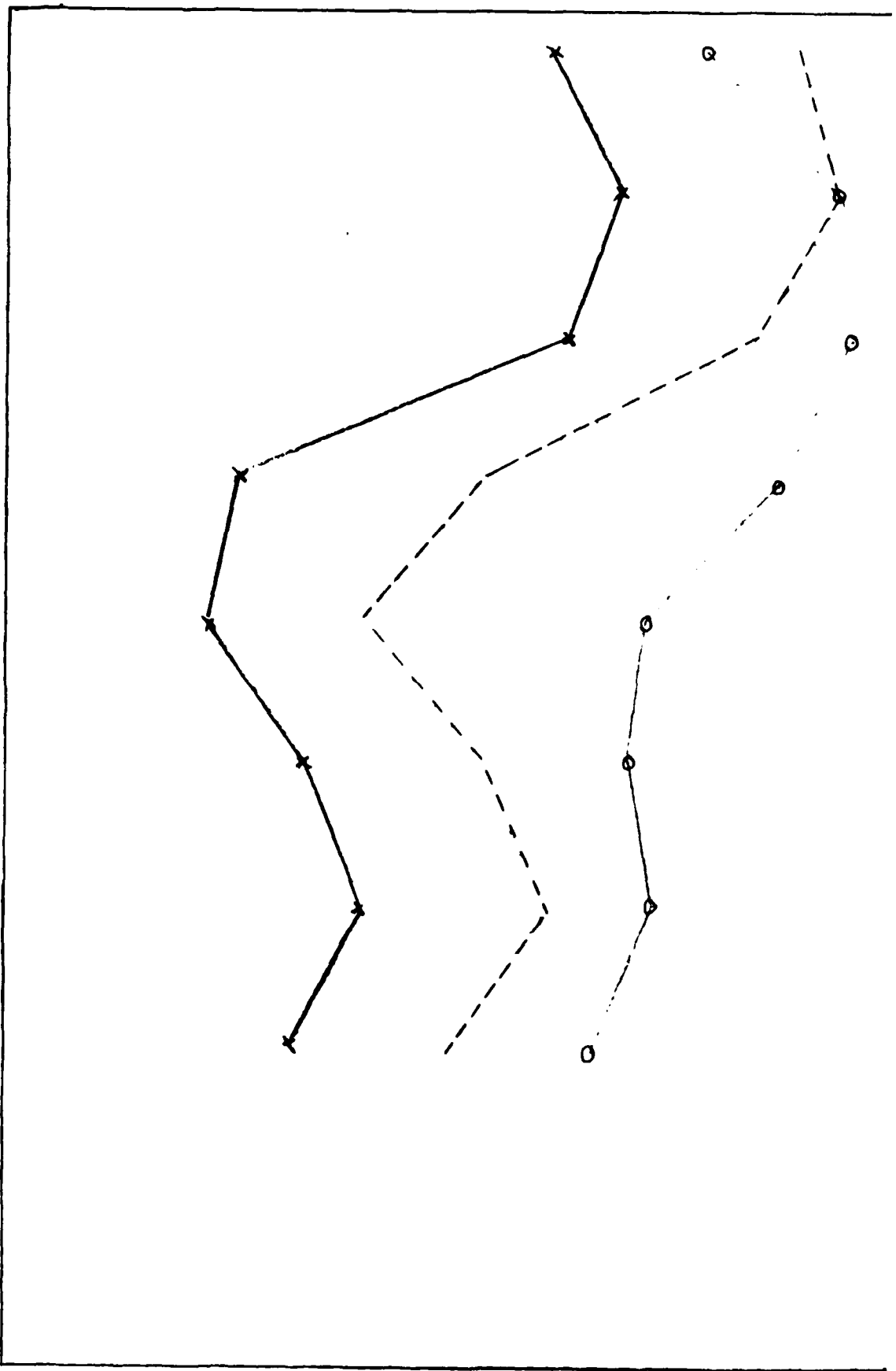
1000

2000

4000

8000

- Hertz





Load - FULL

Date: 5 Nov 83

Data Takers: E. Allard  
S. Allard

Noise Spectrum of Bare Set

	A	63	125	250	500	1K	2K	4K	8K
1	99	81	82	88	95	92	94	89	85
2	99	80	86	87	100	94	91	84	80
3	99	80	81	89	98	93	91	88	81
4	100	85	82	95	99	98	97	95	88
5	106	82	94	95	105	102	98	96	90
6	101	88	105	94	98	95	96	90	84
7	103	81	95	94	101	100	98	94	86
8	103	83	95	94	103	99	97	94	88
9	105	82	95	94	106	98	99	93	87
10	103	82	88	96	104	98	99	94	87
11	103	85	91	84	102	98	97	93	88
12	102	84	94	91	103	99	97	92	87

Average 102

**Comments:**

1. Exhaust pipe and muffler vented to outside
2. Data taken about one foot from E-G set

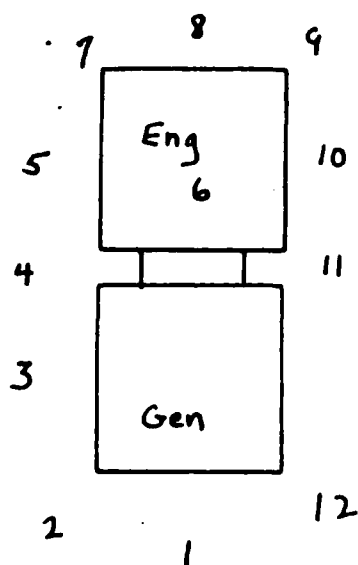


Figure 2

Load 9 Kw

Date: 4-12-84.

Data Takers: John D.  
Ed H.

	A	63	125	250	500	1K	2K	4K	8K
1	87	85	90	87	86	79	74	74	66
2	87	85	89.5	91	86	80	76	75	68
3	88	86	92	96	88	82	78	75	70
4	86	88	93	97	91	82	79	76	72
5	85	85	90	85	84	77	74	69	61
6	82	82	87	87	84	73	66.5	64	57
7	84	82	91	89	86	78	73	75	67
8	85	83	91	87	83	74	72.5	73	66
9	86	83	93	86	85	77	72	72	65
10	84	79	90	86	84	78	73	76	71
11	88	83	88	88	87	81	77	77	72
12	88	86	89	87	89	81	77	76	71

average= 85.5

Comments:

. data taken at one foot

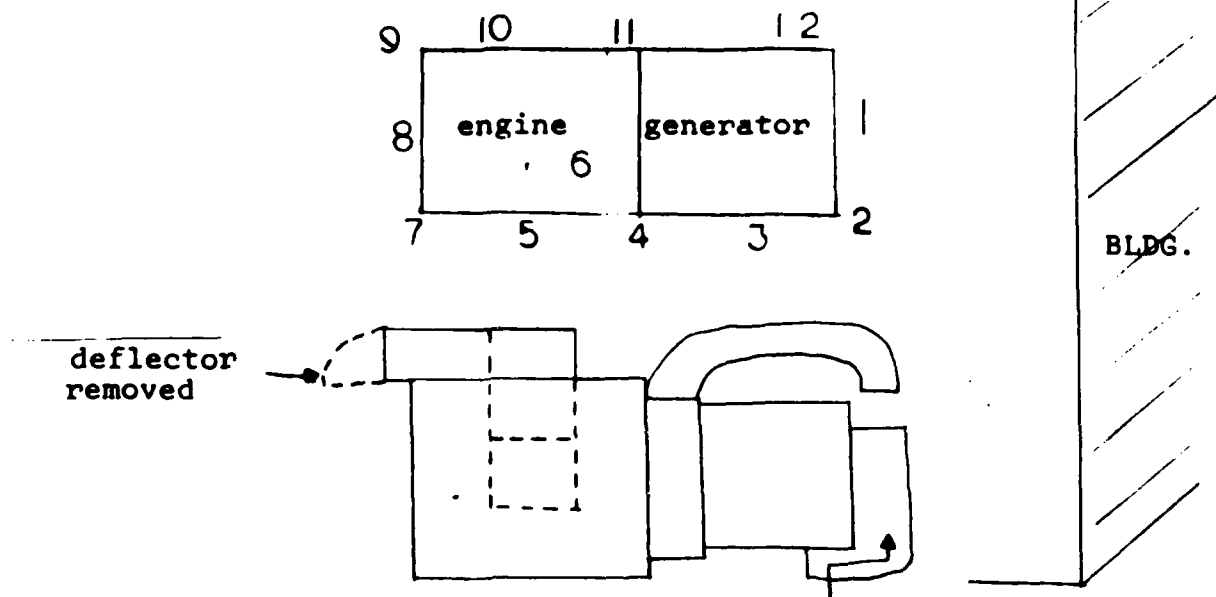


Figure 3 muffler 3m from set

Load 9 KW

Date: 4-16-84.

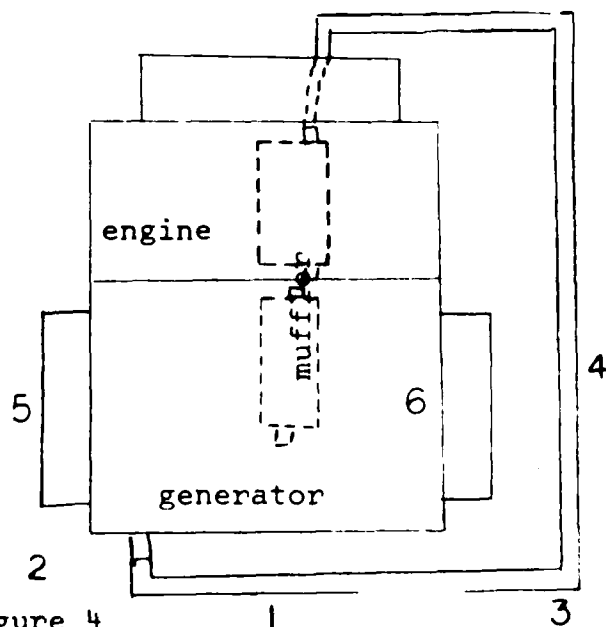
Data Takers: John D.  
Ed H.

	A	63	125	250	500	1K	2K	4K	8K
1	82	81	87	87.5	80	74	72	74	67
2	82	80	87	89	77.5	74	73	75	67
3	81	81	85	83	79	74.5	74	74	66.5
4	84	80	84.5	90	82	77	74	73	66
5	82	77	82	84	80	75	74.5	75	67
6	80	74	82	81	80	73	71	68	60
7	70	68	75	75	67	62	60	61	54
8	71	68	77	76	68	61	60	63	54
9	73	73	75	75	72	65	63	64	57
10	74	71	76	82	68	63	63	61	55
11	72	70	78	73	69	66	64	64	58
12									

BLDG.

Comments:

.7m average = 72 dBA



Load 9 KW

Date: 4-20-84.

Data Takers: John D.  
Ed H.

	A	63	125	250	500	1K	2K	4K	8K
1	69	71	77	73	65	61	62	61	52
2	71.5	72	75	76.5	69	62	62	63	55
3	71.5	69	76.5	75.5	72	61	60	63	54
4	70.5	71	76	76	64.5	60	61	63	55
5	72	69	75	74.5	70	64.5	64.5	63.5	57
6	81	81	85.5	84	78.5	74	72.5	72.5	64
7	82	78	84	86	78	74	73	72	66
8	82	81	85	83	79	73.5	73	75	66.5
9	82	81	84.5	83	80	73.5	72.5	75	66
10	83	78.5	84	84	78	75	73	72.5	66
11									
12									

BN- Back Ground Noise = 71 dBA

Comments:

.7m average = 70.9 dBA

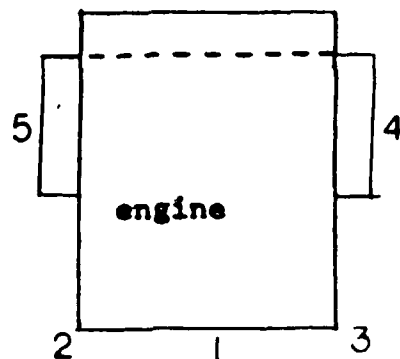


Figure 5

A  
 AMB TEMP. 17°C 10 KW GEN. SET TEST PERSONN.  
 START TIME 5:45 NOISE SUPPRESSION 1. Ed A.  
 KW LOAD 9KW TEST 2. Steve A.  
 DATE 11-7-83

BARE SET

TIME	6:00	6:15	6:30	6:45	7:00					
Oil Sump 0	191	203	205	206	206					
#1 Spk.Plug 1	381	400	402	404	402					
AMB Air 2	77	81	84	85	86					
Gen. Air In 3	63	65	68	68	69					
Eng. Cooling Air (1&3) 4	91	95	98	99	101					
Eng. Cooling Air (2&4) 5	92	96	98	99	100					
#2 Spk.Plug 6	412	417	419	419	421					
Eng. Cooling Air In 7	80	83	86	88	88					
Card Air In 8	112	118	120	122	123					
Dip Stick 9	206	218	221	221	222					

Figure 6

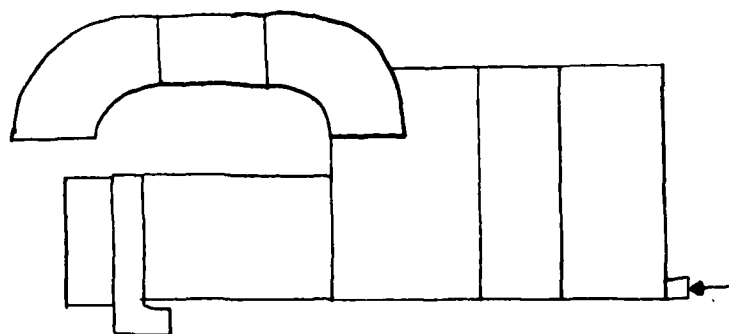
AMB TEMP. 12  
 START TIME 7:10  
 KW LOAD 9 KW

10 KW GEN. SET  
 NOISE SUPPRESSION  
 TEST

TEST PERSONNEL  
 1. John D.  
 2. Ed H.

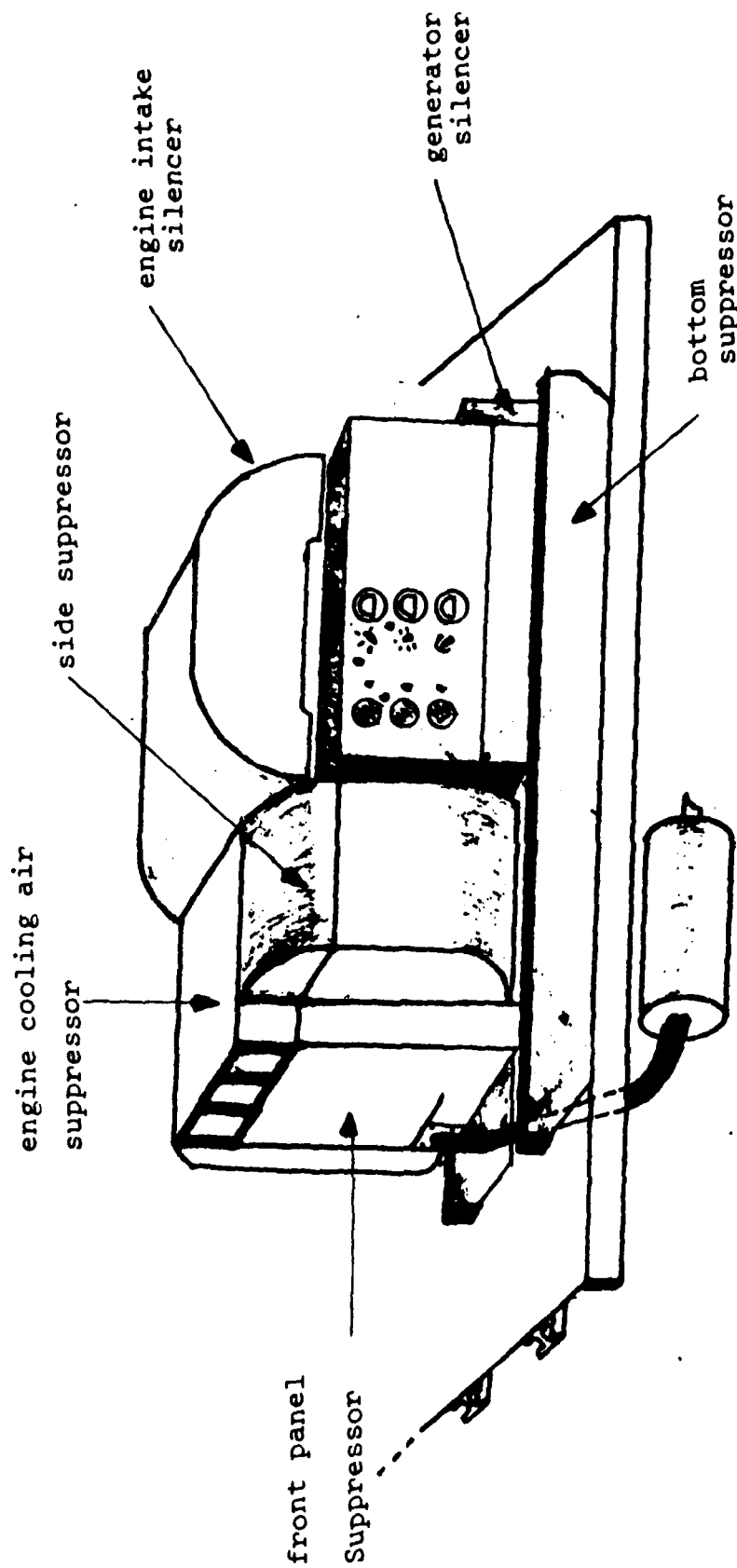
DATE 4-12-84

Ambient temp.	12°C	14°C	15°C	17°C	20°C	20°C	22°C	24°C	24°C	24°C
TIME	7:30	7:45	8:00	8:15	8:30	8:45	9:00	9:15	9:30	9:45
Oil Sump 0	188	194	196	197	198	200	201	201	202	200
#1 Spk. Plug 1	465	466	466	469	468	464	464	463	464	464
AMB Air 2	75	79	82	86	85	88	88	89	91	91
Gen. Air In 3	49	53	57	63	61	63	63	63	61	60
Eng. Cooling Air (163) 4	66	68	72	74	74	77	78	78	78	77
Eng. Cooling Air (264) 5	76	78	83	85	84	84	88	88	88	88
#2 Spk. Plug 6	362	336	336	362	384	390	400	335	334	339
Eng. Cooling Air In 7	59	62	65	67	67	69	70	71	69	71
Card Air In 8	104	111	114	117	117	120	120	121	119	119
Dip Stick 9	186	184	185	188	187	190	190	192	187	190



muffler 3m from set

Figure 7



SUPPRESSED 10 KW ENGINE-GENERATOR SET

Figure 8

END

DATE

FILMED

6-1988

DTIC